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Interactive comment on "Influence of the Earth's ring current strength on the Størmer's allowed and forbidden regions of charged particles motion" *by* Alexander S. Lavrukhin et al.

Anonymous Referee #2

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The study by Lavrukhin was very interesting to read. It deals with a generalisation of the Strömer formalism for particle motion in dipole fields by introducing the effects of a variable ring current. It extends its applicability by not only looking into which transient particles from infinity reach into the forbidden regions (and hit the Earth's surface), but also in the trapping and dynamic modulation of the ring current population. In particular, the authors propose a new loss process for ions, developing after the ring current reaches a critical strength. The manuscript has a solid mathematical formulation. Even though my theoretical skills are not that strong, the presentation is clear and to the level I checked, I could not find any mathematical errors. Results are interesting and may readily be applied not just to Earth, but also for other planetary magnetospheres.

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Discussion paper

Despite that, I do have some reservations about the presentation of the method & theory, having in mind that this paper should be useful not just for researchers with a strong interest in theory, but also to groups dealing with data analysis. Given that, I found it hard to associate certain parameters (e.g. "gamma") with typical observables, such as pitch angle, energy etc. The authors clearly state that particles of same energy can have different gamma, but still that wont be enough for many interested readers. Certain equations describe gamma through the "generalized momentum", to which observers would have trouble to link with observable/measurable quantities e.g. by particle detectrors. Same may apply for the Strömer radius etc. e.g how does it relate to gyroradius. These could either be explained in text, or maybe through an extra illustration/figure.

What I found a bit confusing is the definition of allowed vs. forbidden regions. E.g. in Fig. 1, white shaded areas are allowed for 100 keV protons, but that seems strange at a first sight/read - clearly, inward of the white shaded area, where the field is (much) stronger, trapping is obviously also allowed for 100 keV ions. It may be natural that the trapping limit/limit of adiabaticity may be confused with the character of the allowed region as allowed in this paper. Maybe this ties well to the definition of gamma or energy. E.g. is 100 keV in Fig. 1 the energy at infinity of at the injection point within the magnetosphere? Also, I would be interested to see some comments about the presence of the corotation ExB drift, since the authors do attemp to apply their formulation to keV particles too. Finally, I think a relevant paper may be that of Birmingham 1982 (https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/JA087iA09p07421), where particle motion is analysed in a dipole + ring current, albeit with a different formalism.

Some extra minor comments:

P2, line 5: Change “analytical analysis”

P3, line 19: “directed to the west”: “located to the west” is maybe a better expression?

P5 , line 20: do I understand well that the inner boundary of the current is at Earth’s surface?

P9, First lines of section 4: not sure about the explanation of the partial ring current. You write that there is a region where gradient drift dominates, while "in the intermediate region between the gradient and E $\times$ B drift regions, a partial ring current arises due to the fact that protons on one side of Earth, and electrons on another have oppositely directed gradient drift velocities.". But the oppositely drift velocities is also a feature of the field gradient, applicable also in the first region where "gradient drift dominates". So, I dont really understand what is the difference between the two regions and where does ExB come in.

P8, line 19: what is it meant “momentum at one Strömer radius?

P9, line 22: add reference in parenthesis

P10 line 13: which value –> the value of which

P18, line 21: correct "for At"

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